FORM PTO 1390 (REV 10-2000) U S DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

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INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATES	PRIORITY DATE CLAIMED
PCT/EP99/07957	20/10/1999	26 October 1998

TITLE OF INVENTION LINEAR INDUCTIVE TRANSDUCER

APPLICANT(S) FOR DO/EO/US Dondi Valerio

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. [x] This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. [ ] This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. [x] This is an express request to promptly begin national examination procedures (35 U.S.C. 371 (f)).
4. [x] The US has been elected by the expiration of 19 months from the priority date (PCT Article 31).
5. [x] A copy of the International Application as filed (35 U.S.C. 371 (c)(2))
   a. [ ] is attached hereto (required only if not communicated by the International Bureau).
   b. [X] has been communicated by the International Bureau.
   c. [ ] is not required, as the application was filed in the United States Receiving Office (RO/US).
6. [ ] An English language translation of the International Application as filed (35 U.S.C. 371 (c)(2)).
7. [x] Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371 (c)(3))
   a. [ ] are attached hereto (required only if not communicated by the International Bureau).
   b. [ ] have been communicated by the International Bureau.
   c. [ ] have not been made; however, the time limit for making such amendments has NOT expired.
   d. [x] have not been made and will not be made.
8. [ ] An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371 (c) (3)).
9. [x] An oath or declaration of the inventor(s) (35 U.S.C. 371 (c) (4)).
10. [x] An English language translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371 (c) (5)).

Items 11 to 16 below concern document(s) or information included:

11. [x] An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. [x] An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 & 3.31 is included.
13. [x] A FIRST preliminary amendment.
    [ ] A SECOND or SUBSEQUENT preliminary amendment.
14. [ ] A substitute specification.
15. [ ] A change of power of attorney and/or address letter.
16. [x] Other items or information:
    Copy of International Search Report

U.S. APPLICATION NO. (if known, see 37 CFR 1.5)	INTERNATIONAL APPLICATION NO.	ATTORNEY'S DOCKET NUMBER
09/830503	PCT/EP99/07957	M1885.0038/P038

17. [x] The following fees are submitted:

BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) – (5)):

		CALCULATIONS PTO USE ONLY
[ ]	Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO $1000.00	
[x]	International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO $860.00	
[ ]	International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO $710.00	
[ ]	International preliminary examination fee paid to USPTO (37 CFR 1.482) but all claims did not satisfy provisions of PCT Article 33(1)-(4) $690.00	
[ ]	International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(1)-(4) $100.00	
	ENTER APPROPRIATE BASIC FEE AMOUNT =	$ 860.00
Surcharge of $ _____ for furnishing the oath or declaration later than [ ] 20 [ ] 30 months from the earliest claimed priority date (37 CFR 1.492 (e)).		$

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE	
Total claims	14-20 =		x	$ 0.00
Independent claims	2-3 =		x	$ 0.00
MULTIPLE DEPENDENT CLAIM(s) (if applicable)			x	$
		TOTAL OF ABOVE CALCULATIONS =		$ 860.00
[ ] Applicant claims small entity status. See 37 CFR 1.27. The fees indicated above are rduced by ½.				$
		SUBTOTAL =		$ 860.00
Processing fee of $ _____ for furnishing the English translation later than [ ] 20 [ ] 30 months from the earliest claimed priority date (37 CFR 1.492 (f)). +				$
		TOTAL NATIONAL FEE =		$ 860.00
Fee for recording the enclosed assignment (37 CFR 1.21 (h)). Assignment must be accompanied by appropriate cover sheet (37 CFR 3.28, 3.31) + (40.00 per property).				$ 40.00
		TOTAL FEES ENCLOSED =		$ 900.00
			Amount to be Refunded:	$
			Charged:	$

a. [x] A check in the amount of $ 900.00 to cover the above fees is enclosed.

b. [ ] Please charge my Deposit Account No. 04-1073 in the amount of $ _____ to cover the above fees. A duplicate copy of this sheet is enclosed.

c. [x] The Commissioner is hereby authorized to charge any additional fees which may be required or credit any overpayment to my Deposit Account No. 04-1073. A duplicate copy of this sheet is enclosed.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137 (a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:

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28,371
REGISTRATION NUMBER

Form PTO-1390 (REV 12-29-99)

Docket No.: M1885.0038/P038
(PATENT)

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of:
Dondi Valerio

Application No.: Not Yet Assigned

Group Art Unit: N/A

Filed: April 25, 2001

Examiner: Not Yet Assigned

For: LINEAR INDUCTIVE TRANSDUCER

FIRST PRELIMINARY AMENDMENT

Box Non-Fee Amendment
Commissioner for Patents
Washington, DC 20231

Dear Sir:

Please enter all amendments made under Article 34 in the International Application which are appended hereto prior to examination in the application, and further amend the application as follows.

In The Claims:

Please rewrite claims 1-14 as follows:

1. A linear inductive transducer comprising:

electric windings including

a first primary winding, and

a pair of secondary windings,

a magnetic core, for performing linear displacements relative to the electric windings,

a pair of input terminals electrically connected to said first primary winding and adapted for being electrically connected to a power supply unit,

at least one output terminal electrically connected to said electric windings, the transducer being adapted for providing, through the output terminal, an electric signal indicative of the mutual position between said electric windings and said magnetic core, wherein the electric windings include a second primary winding between said first primary winding and one of said input terminals, said first and second primary windings being electrically connected to each other and to said pair of secondary windings, said electric signal including a first and a second component, indicative of the mutual position between the magnetic core and said primary windings and said secondary windings, respectively.

2. The transducer according to claim 1, wherein said first primary winding and said second primary winding are mutually connected in series at a connection point, and said secondary windings are electrically connected to said connection point.

3. The transducer according to claim 2, wherein said first primary winding and said second primary winding are each adapted to provide a signal that is variable as the mutual position between said first primary winding or said second primary winding and said magnetic core varies, the first component of said electric signal being proportional to the difference between the signals provided by the first and second primary windings, respectively.

4. The transducer according to claim 3, wherein the secondary windings are mutually connected in phase opposition.

5. The transducer according to claim 4, wherein each of said secondary windings provides an induced signal that is variable as the mutual position between said electric windings and said magnetic core varies, the second component of the signal electric being proportional to the difference between said induced signals.

6. The transducer according to claim 1, wherein said first primary winding and said second primary winding have the same number of turns, and each of said secondary

windings has the same number of turns as the other.

7. The transducer according to claim 1, wherein said power supply unit includes two sinusoidal voltage generators connected in phase opposition.

8. A linear inductive transducer comprising:

electric windings including

a first primary winding, and

a pair of secondary windings,

a magnetic core for performing linear displacements relative to the electric windings,

a pair of input terminals electrically connected to said primary winding and adapted for being electrically connected to a power supply unit, and

output terminals electrically connected to said electric windings, the transducer being adapted for providing at least one of said output terminals with an electric signal indicative of the mutual position between said electric windings and said magnetic core, wherein the electric windings include a second primary winding between said first primary winding and an input terminal of said pair, the first and second primary windings being mutually connected in series at a connection point, said output terminals including three output terminals electrically connected to the ends of said pair of secondary windings, and to said connection point between the primary windings, respectively, the transducer being adapted for selectively providing said electric signal at one or a pair of said three output terminals.

9. The transducer according to claim 8, wherein the secondary windings are mutually connected in phase opposition.

10. The transducer according to claim 8, wherein two of said three output terminals are adapted for being electrically connected to one another for achieving an electric connection between the primary windings and the secondary windings, the transducer being adapted for providing said electric signal at the other of said three output terminals.

11. The transducer according to claim 10, wherein said electric signal includes a first and a second component, indicative of the mutual position between the magnetic core and the primary windings and secondary windings respectively.

12. The transducer according to claim 8, wherein two of said three output terminals are adapted for being insulated, the transducer being adapted for providing said electric signal at the other of said three output terminals.

13. The transducer according to claim 8, wherein said power supply unit includes two sinusoidal voltage generators connected in phase opposition.

14. The transducer according to claim 8, wherein the output terminal connected to the connection point is adapted for being insulated, the transducer being adapted for providing said electric signal at the two output terminals at the ends of said pair of secondary windings.

REMARKS

The above-identified application has been amended. The multiple dependency of claims 6, 7, 10, 12, 13, 14 and the referenced numbers within claims 1-14 have been deleted. The claim language has also been amended for easier understanding of the defined subject matter. The marked-up version of the amended claims is attached hereto as APPENDIX A. Favorable action on the application is solicited.

Dated: April 25, 2001

Respectfully submitted,

By_____

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APPENDIX A

Version With Markings to Show Changes Made

1. A linear inductive transducer [(**T**)] [including]comprising:

[•] electric windings [(**1-4**)][with]including

[•] a first primary winding [(**1**)], and

[•] a pair of secondary windings[(**2,4**)],

[•] a magnetic core[(**8**)], for performing linear displacements relative to the electric windings,

[•] a pair of input terminals [(**5,6**)] electrically connected to said first primary winding [(**1**)] [•] and adapted for being electrically connected to a power supply unit [(**C,11,13**)],

[•] at least [an]one output terminal [(**7**)] electrically connected to said electric windings [(**1-4**)], the transducer [(**T**)] being adapted for providing, through the output terminal [(**7**)], an electric signal [(**Vo**)] indicative of the mutual position between said electric windings [(**1-4**)] and said magnetic core [(**8**)], [characterized in that] wherein the electric windings include a second primary winding [(**3**)] between said first primary winding [(**1**)] and [an input terminal] one of said [pair] input terminals [(**5,6**)], [the] said first and second primary windings [(**1,3**)] being electrically connected to each other and to said pair of secondary windings [(**2,4**)], said electric signal [(**Vo**)] including a first [(**Vs**)] and a second [(**Vs'**)]component, indicative of the mutual position between the magnetic core [(**8**)] and said primary windings [(**1,3**)] and said secondary windings [(**2,4**)], respectively.

2. The transducer according to claim 1, wherein [the] said first primary winding [(**1**)] and [the] said second primary winding [(**3**)] are mutually connected in series at a connection point [(9)], [the] and said secondary windings [(2,4) being] are electrically connected to said connection point [(**9**)].

3. The transducer according to claim 2, wherein [each of] said first primary winding [(**1**)] and said second primary winding [(**3**)] [provides] are each adapted to provide a *signal* [(**V1,V3**)]that is variable as the mutual position between said first primary winding [(**1**)] or said second primary winding [(**3**)] and said magnetic core [(**8**)] varies, the first component [**Vs**] of said electric signal [(Vo)] being proportional to the difference between the signals [(**V1,V3**)] provided by the first and second primary windings, [(**1,3**)]respectively.

4. The transducer according to claim 3, wherein the secondary windings [(**2,4**)] are mutually connected in phase opposition.

5. The transducer according to claim 4, wherein each of said secondary windings [(**2,4**)] provides an induced signal [(**V2,V4**)] that is variable as the mutual position between said electric windings [(**1-4**)] and said magnetic core [(**8**)] varies, the second component [(**Vs'**)] of the electric signal [(**Vo**)] being proportional to the difference between said induced signals [(**V2,V4**)].

6. The transducer according to [one of the preceding claims] claim 1, wherein said first primary winding [(**1**)] and said second primary winding [(**3**)] have the same number [(**N1**)] of turns, and each of said secondary windings [(**2,4**)] has the same number [(**N2**)] of turns as the other.

7. The transducer according to [one of the preceding claims] claim 1, wherein said power supply unit includes two sinusoidal voltage generators [(**11,13**)] connected in phase opposition.

8. A linear inductive transducer [(**T'**)] [including] comprising:

[•] electric windings [(**21-24**)] [with] including

- [•] a first primary winding [(**21**)], and
- [•] a pair of secondary windings[(**22,24**)],

[•] a magnetic core [(**28**)] for performing linear displacements relative to the electric windings,

[•] a pair of input terminals [(**32,34**)] electrically connected to said primary winding [(**21**)] and adapted for being electrically connected to a power supply unit [(**11,13;11'**)], and

[•] output terminals [(**31,33,35**)] electrically connected to said electric windings [(**21-24**)], the transducer [(**T'**)] being adapted for providing[,] at least one of said output terminals [(**31,33,35**),] with an electric signal [(**Vo;Vo';Vo"**)] indicative of the mutual position between said electric windings [(**21-24**)] and said magnetic core [(**8**)], [characterized in that] wherein the electric windings include a second primary winding [(**23**)] between said first primary winding [(**21**)] and an input terminal of said pair [(**32,34**)], the [primary] [(**21**)] first and [the] second primary [(**23**)] windings being mutually connected in series at a connection point [(**29**)], said output terminals [include]including three output terminals [(**31,33,35**)] electrically connected to the ends of said pair of secondary windings [(**22,24**)], and to said connection point [(**29**)] between the primary windings, [(**21,23**)]respectively, the transducer [(**T'**)] being adapted for selectively providing said electric signal [(**Vo;Vo';Vo"**)] at one [(**31;33**)] or a pair [(**31,35**)] of said three output terminals [(**31,33,35**)].

9. The transducer according to claim 8, wherein the secondary windings [(**22,24**)] are mutually connected in phase opposition.

10. The transducer according to claim 8 [or claim 9], wherein two [(**33,35**)] of said three output terminals [(**31,33,35**)] are adapted for being electrically connected to one another for achieving an electric connection between the primary windings [(**21,23**)] and the secondary windings [(**22,24**)], the transducer [(**T'**)] being adapted for providing said electric signal [(**Vo**)] at the other [(**31**)] of said three output terminals [(**31,33,35**)].

11. The transducer according to claim 10, wherein said electric signal [(Vo)] includes a

first [(**Vs**)] and a second [(**Vs'**)] component, indicative of the mutual position between the magnetic core [(**28**)] and the primary windings [(**21,23**)] and[, respectively, the second]secondary windings respectively[(**22,24**)].

12. The transducer according to claim 8 [or claim **9**], wherein two [(**31,35**)] of said three output terminals [(**31,33,35**)] are adapted for being insulated, the transducer [(**T'**)] being adapted for providing said electric signal [(**Vo'**)] at the other [(**33**)] of said three output terminals [(**31,33,35**)].

13. The transducer according to [one of claims from 8 to 12] claim 8, wherein said power supply unit includes two sinusoidal voltage generators [(**11,13**)] connected in phase opposition.

14. The transducer according to claim 8 [or claim 9], wherein the output terminal [(**33**)] connected to the connection point [(**29**)] is adapted for being insulated, the transducer [(**T'**)] being adapted for providing said electric signal [(**Vo"**)] at the two output terminals [(**31,35**)] at the ends of said pair of secondary windings [(**22,24**)].

CLAIMS

1. A linear inductive transducer (**T**) including
- electric windings (**1-4**) with
  - a primary winding (**1**), and
  - a pair of mutually connected secondary windings (**2,4**),
- a magnetic core (**8**), for performing linear displacements relative to the electric windings,
- a pair of input terminals (**5,6**) electrically connected to said primary winding (**1**) and adapted for being electrically connected to a power supply unit (**C,11,13**),
- at least an output terminal (**7**) electrically connected to said electric windings (**1-4**),

the transducer (**T**) being adapted for providing, through the output terminal (**7**), an electric signal (**Vo**) indicative of the mutual position between said electric windings (**1-4**) and said magnetic core (**8**),

characterized in that the electric windings include a second primary winding (**3**) between said primary winding (**1**) and an input terminal of said pair (**5,6**), the primary windings (**1,3**) being electrically connected to each other and to said pair of secondary windings (**2,4**), said electric signal (**Vo**) including a first (**Vs**) and a second (**Vs'**) component, indicative of the mutual position between said magnetic core (**8**) and said primary windings (**1,3**) and said secondary windings (**2,4**), respectively.

2. The transducer according to claim 1, wherein the primary winding (**1**) and the second primary winding (**3**) are mutually connected in series at a connection point (**9**), the secondary windings (**2,4**) being electrically connected to said connection point (**9**).

3. The transducer according to claim 2, wherein each of said primary winding (**1**) and second primary winding (**3**) provides a signal (**V1,V3**) that is variable as the mutual position between said primary winding (1) or second primary

winding (**3**) and said magnetic core (**8**) varies, the first component (**Vs**) of said electric signal (**Vo**) being proportional to the difference between the signals (**V1,V3**) provided by the primary windings (**1,3**).

4. The transducer according to claim 3, wherein the secondary windings (**2,4**) are mutually connected in phase opposition.

5. The transducer according to claim 4, wherein each of said secondary windings (**2,4**) provides an induced signal (**V2,V4**) that is variable as the mutual position between said electric windings (**1-4**) and said magnetic core (**8**) varies, the second component (**Vs'**) of the electric signal (**Vo**) being proportional to the difference between said induced signals (**V2,V4**).

6. The transducer according to one of the preceding claims, wherein said primary winding (**1**) and said second primary winding (**3**) have the same number (**N1**) of turns, and each of said secondary windings (**2,4**) has the same number (**N2**) of turns as the other.

7. The transducer according to one of the preceding claims, wherein said power supply unit includes two sinusoidal voltage generators (**11,13**) connected in phase opposition.

8. A linear inductive transducer (**T'**) including

- electric windings (**21-24**) with
  - a primary winding (**21**), and
  - a pair of mutually connected secondary windings (**22,24**),
- a magnetic core (**28**) for performing linear displacements relative to the electric windings,
- a pair of input terminals (**32,34**) electrically connected to said primary winding (**21**) and adapted for being

electrically connected to a power supply unit

DESCRIPTION

LINEAR INDUCTIVE TRANSDUCER

Technical Field

The present invention relates to a linear inductive transducer including electric windings with a primary winding and a pair of secondary windings, a magnetic core, for performing linear displacements relative to the electric windings, a pair of input terminals electrically connected to the primary winding and adapted for being electrically connected to a power supply unit, at least an output terminal electrically connected to the electric windings, the transducer being adapted for providing, through the output terminal, an electric signal indicative of the mutual position between the electric windings and the magnetic core.

The invention also relates to a linear inductive transducer including electric windings with a primary winding and a pair of secondary windings, a magnetic core, for performing linear displacements relative to the electric windings, a pair of input terminals electrically connected to the primary winding and adapted for being electrically connected to a power supply unit, and output terminals electrically connected to the electric windings, the transducer being adapted for providing, through at least one of the output terminals, an electric signal indicative of the mutual position between the electric windings and the magnetic core.

Background Art

Transducers with these characteristics, in particular of the Linear Variable Differential Transformer (LVDT) type have been known for a long time and utilized, among other things, in many measuring apparatuses for providing

electric signals indicative of the mutual position between mechanical parts. These transducers include a primary winding and a pair of secondary windings connected together in series opposition. The windings are wound on a substantially cylindrical bobbin at the interior of which a ferromagnetic core displaces along an axial direction. The primary winding is energized with a sinusoidal voltage and generates, at the ends of the secondary windings, induced voltages that vary as the axial position of the core changes. More specifically, the voltages induced in the secondary windings are equal and oppositely phased when the core is at an axially centered position. Thus, the total voltage at the free terminals of the secondary windings is null at said axially centered position, while its amplitude varies as the axial position of the core changes, and its phase changes in response to the sense of the axial displacement with respect to the centered position.

In U.S. Patent No. 4,386,467 there is disclosed a possible application of an LVDT in a comparator for checking a hole of a mechanical piece, in which the core and the transducer windings are respectively coupled to two mutually movable arms that carry feelers for touching diametrically opposite points of the hole.

Other types of inductive transducers are known as Half Bridge Transducers or HBT. These transducers include a pair of series connected windings, wound on a bobbin and energized with a sinusoidal voltage at the free ends thereof, and a ferromagnetic core axially movable within the bobbin. The output voltage is drawn at an intermediate point between the windings and its amplitude varies as the axial position of the core changes. The HBTs are broadly utilized in measuring devices, especially in simple devices like axial, or cartridge, heads, in consideration of the attributes of simplicity and inexpensiveness. Furthermore, unlike the LVDT transducers, the half bridge transducers have low output impedance values (e.g., 300 ohm as compared to 2000 ohm that represent a typical value for an LVDT),

thus the negative effects due to increased load impedance caused by the cable for the connection to the conditioning units are negligible. In fact, different cable lengths determine different load impedance values at the output of the transducer, and said load impedance in turn determines a variation in the amplitude of the output signal that increases the more the transducer output impedance is higher.

In a half bridge transducer the output impedance is relatively low since it is determined by the parallel of the impedances of the two windings, while it is definitely higher in a differential transformer transducer, where it is determined by the sum of the impedances of the two series connected secondary windings.

Another advantageous feature of the HBT in comparison with the LVDT, particularly in multiple applications in which the signals sent by a plurality of transducers have to be managed, is the possibility of utilizing -between each of the HBT and the conditioning unit- one electric connection wire less (three, as compared to four that are necessary for the differential transformer transducers) thereby simplifying the application.

A drawback of the HBTs is the poor sensitivity, i.e. the low ratio between the detected output signal variation and the associated core displacement. In a half bridge transducer, the sensitivity mainly depends on the geometric characteristics, more specifically on the ratio existing between the dimensions of the windings and those of the core, both generally imposed by the dimensions of the measuring device including the transducer. Hence, it is impossible to independently define the sensitivity and modify it for specific applications, for example in an application of a comparator as the one described in the formerly mentioned patent US-A-4,386,467. In fact, in this specific case, as there is an "arms ratio" (i.e., the ratio between the amount of displacement of the feelers and the amount of the associated mutual displacement between the

transducer's core and windings) that is known and generally differs from one, it can be advantageous to define the transducer sensitivity in order to take into account this known ratio, in this way simplifying the processings performed by the conditioning circuit.

Disclosure of Invention

An object of the present invention is to provide a linear inductive transducer that overcomes the disadvantages of the known transducers and, more specifically, enables to define its sensitivity regardless of the geometric characteristics, and none the less ensures a lower output impedance value and a lesser number of external electric connections with respect to the known differential transformer transducers.

This and other objects and advantages are achieved by a transducer according to claim 1.

A further object of the invention is to provide a linear inductive transducer that can present the functional charactersitcs of a differential transformer transducer, or a half bridge transducer, or a transducer of another type, by carrying out simple and rapid modifications.

This further object is achieved by a transducer according to claim 8.

Brief Description of the Drawings

The invention is now described in more detail with reference to the enclosed sheets of drawings, given by way of non limiting example, wherein:

figure 1 is a circuit diagram of an inductive transducer according to a preferred embodiment of the invention,

figures 2a, 2b and 2c are graphs that show the trend of some of the voltages at various points of the circuit

diagram of figure 1, taken at a plurality of mutual positions between the movable parts of the transducer,

figure 3 is a circuit diagram of an inductive transducer according to a different embodiment of the invention and a first possible configuration,

figure 4 is a circuit diagram of the transducer of figure 3, according to a second possible configuration, and

figure 5 is a circuit diagram of the transducer of figure 3, according to a third possible configuration.

The circuit of figure 1 schematically shows an inductive transducer **T** including first and second primary windings **1** and **3**, first and second secondary windings **2** and **4**, two input terminals **5** and **6** and an output terminal **7**. A magnetic core **8** can translate, with respect to windings **1-4**, in the **±X** direction.

A conditioning, or power supply and processing, unit **C** includes two sinusoidal voltage generators **11** and **13**, connected to ground (identified by reference number **12**) and in phase opposition to input terminals **5** and **6**, respectively, while signal processing means, connected to output terminal **7**, are schematically shown with a load impedance **15**.

A connection point **9** intermediate between primary windings **1** and **3** (that have the same number of turns **N1**) is connected to an end of one (**2**) of the secondary windings **2** and **4**, the latter being connected to each other in phase oppostion and having the same number of turns **N2**.

The dots **F** in the figure stand to indicate the phases associated with the voltages across the different windings **1-4** and the voltage generators **11** and **13**.

In an application in a comparator as the one shown in U.S. patent No. 4,386,467, core **8** and windings **1-4** are connected to the two movable arms carrying the feelers, respectively.

The operation of the circuit shown in figure 1 is as follows.

The primary windings 1 and 3 are energized with sinusoidal power supply voltages Va_{11} and Va_{13}, that are identical and in phase oppostion, supplied by generators 11 and 13.

The voltage Vo at output terminal 7, or measuring signal, is equal to the sum of two components: voltage Vs, present -with respect to ground- at intermediate point 9 between primary windings 1 and 3, and voltage Vs' induced in the overall secondary windings 2 and 4:

$$Vo = Vs + Vs' \quad (1)$$

More particularly, the value of Vs, or unbalance voltage of the primary windings, is defined by

$$Vs = (V1 - V3)/2 \quad (2)$$

where V1 and V3 indicate the voltages, or potential drops, across the primary windings 1 and 3, respectively, while the value of Vs', or unbalance voltage of the secondary windings, is defined by

$$Vs' = V4 - V2 \quad (3)$$

where V4 and V2 indicate the voltages induced in the secondary windings 4 and 2, respectively.

When core 8 is at the central, symmetric position with respect to both the primary windings 1 and 3 and the secondary windings 2 and 4 shown in figure 1, both the components of the measuring signal Vo become null because the voltages at the ends of each of the primary windings 1 and 3 and each of the secondary windings 2 and 4, respectively, have identical value:

$$V1 = V3 \quad (4)$$

$$V2 = V4 \quad (5)$$

Thus, in these conditions Vo = 0.

The displacement of core 8, in response, for example, to the mutual displacement of the movable arms of the comparator including the transducer according to the invention, produces a variation in the reluctance of the magnetic circuits of windings 1 and 3. The consequent inductance variation of the two windings produces two different voltage values V1 and V3 and thus an unbalance voltage Vs other than zero, according to formula (2).

The displacement of core **8** also varies the mutual inductance between the primary windings altogether considered (**1+3**) and each of the secondary windings **2** and **4**, differentially connected to each other. Therefore, because **V2 ≠ V4**, unbalance voltage **Vs'** generated in the secondary windings differs from zero, according to formula (3).

The voltages **V2** and **V4** induced in the two secondary windings **2** and **4** by the overall primary winding **1+3** depend -at a specific position of core **8**- on a coupling coefficient **K**. More particularly, making the simplified hypothesis that primary windings **1** and **3** are equal and symmetric with respect to each other, as well as the secondary windings **2** and **4**, then

$$V2 = K \bullet V1 \quad (6)$$

$$V4 = K \bullet V3 \quad (7)$$

with

$$K = k \bullet n \quad (8)$$

where **k** varies depending on the transducer geometric features, and **n** is the turns ratio between secondary and primary windings: **n = N2/N1**.

The above hypothesis foresees the same **k** value in both the formulas (6) and (7) for the sake of simplification and making the substantial aspects of this invention clearer.

When the position of core **8** differs from the central symmetric one of figure 1, by substituting the formulas (2), (3), (6), (7) and (8) in (1), there results:

$$Vo = Vs\ (1 - 2 \bullet k \bullet N2/N1) \quad (9)$$

Thus, from formula (9) there results that output voltage **Vo** at terminal **7** has a value that, for displacements of core **8** of the same amount, varies among other things as the ratio of the turns varies **n = N2/N1**. As a consequence, contrary to what occurs in the known half bridge transducers, when the application requirements vary, the sensitivity can be set regardless of geometric considerations by choosing the appropriate turns ratio value **n**.

The figures 2a, 2b and 2c show the trend of the voltages hereinbefore mentioned in response to the various positions of core **8**. More specifically, figure 2a refers to the situation shown in figure 1 (core **8** is in a central and symmetric position) while figures 2b and 2c refer to situations according to which core **8** is displaced along **-X** and **+X**, respectively.

The trends of output voltage **Vo** of figures 2b and 2c show that, as the position of core **8** changes, the amplitude of the formerly mentioned voltage **Vo** varies, while the phase indicates the sense (**-X** or **+X**) of displacement of core **8** with respect to the central position of figure 1.

From the foregoing description and the figure 1 illustration, it appears that transducer **T** is connected to conditioning unit **C** by means of three conductors ending at terminals **5**, **6** and **7**, two being necessary for the power supply and one for the transmission of output signal **Vo**.

Another advantage of the transducer shown in figure 1 with respect to the known differential transformer transducers consists in the possibility of obtaining limited output impedance values. In fact, while the impedance value is determined, even in the arrangement shown in figure 1, by the sum of the impedances of the two secondary windings **2** and **4**, in this case it is possible to choose a small number of turns **N2** (and consequently low impedance values of the secondary windings **2** and **4**) without causing -contrary to what occurs in the LVDTs- an unacceptable decrease in the transducer sensitivity. In fact, in the transducer according to the present invention, output signal **Vo** does not only depend on the transformer coupling, but, according to formula (1), it is the sum of two components. Thus, the choice of the appropriate turns ratio **n** (formula (9)) enables to achieve -in an extremely flexible way- the best possible balance among the required sensitivity and output impedance values.

According to an alternative to the herein illustrated and so far described embodiment, the primary windings **1** and **3**

are energized with a single sinusoidal voltage between terminals **5** and **6**, instead of the phase opposition voltages Va_{11} and Va_{13}. In this case, voltage **Vs** -at the center position of core **8**- has a known amplitude value that differs from zero (for example, equal to half that of the energizing voltage). With respect to the previously described embodiment, this alternative does not present substantial differences, apart from the phase of output voltage **Vo**, that does not enable to immediately distinguish displacements in one or in the other sense with respect to the central position of core **8**.

The transducer **T'** shown in figures 3, 4 and 5 includes first and second primary windings **21** and **23** connected in series at a connection point **29**, first and second secondary windings **22** and **24**, five terminals **31**, **32**, **33**, **34** and **35** and a magnetic core **28** that can perform translation displacements with respect to windings **21-24**.

In the configuration shown in figure 3, transducer **T'** is substantially similar to transducer **T** of figure 1. In fact, in this configuration, terminal **33** (that ends at connection point **29**) and terminal **35** are short circuited, for example by means of a wire **36**. The voltage generators **11** and **13** of the conditioning unit **C**, shown in figure 1, are connected to terminals **32** and **34**, while output voltage **Vo** -substantially identical to the one attained with transducer **T**- is detected at the ends of load impedance **15** between terminal **31** and ground **12**.

In the configuration shown in figure 4, secondary windings **22** and **24**, ending at terminals **31** and **35**, are not connected to external units and thus are insulated. By providing in this configuration, too, a connection between voltage generators **11** and **13** and terminals **32** and **34**, it is possible to attain, by utilizing a suitable setting resistor **27**, an output voltage **Vo'** -at the ends of a load impedance **15'** between terminal **33** and ground **12**- that varies as the position of core **28** changes, according to the

well known functioning principle of a half bridge transducer or HBT.

Furthermore, in the configuration shown in figure 5, terminal **33** is insulated. A sinusoidal voltage generator **11'** is connected to terminals **32** and **34** for feeding a primary winding **21+23** that consists of both windings **21** and **23**, while an output voltage **Vo''** is detected, by utilizing a suitable setting resistor **30**, at the ends of a load impedance **15''** between terminals **31** and **35** (the latter being connected to ground **12**). Voltage **Vo''** varies as the position of core **28** changes, according to the well known functioning principle of a linear variable differential transformer or LVDT.

From the concise description of figures 3, 4 and 5, it appears that transducer **T'** is particularly flexible, since with a single structure it is possible to attain transducers of different types (LVDT, HBT or transducers of the new type described with reference to figure 1), and in each case achieve the type of transducer with the characteristics that best suit the specific application.

It is also to be noted that the setting resistors **27** and **30** are connected, respectively, to terminal **33** (insulated in the configuration of figure 5) and between terminals **31** and **35** (insulated in the configuration of figure 4). This enables to independently set the sensitivity for the HBT configuration (shown in figure 4) and LVDT configuration (shown in figure 5) on the same transducer **T'** and directly choose the proper configuration in the application phase, without the need of a further setting.

Transducers that include modifications with respect to what is herein schematically illustrated and so far described, for example in connection with the relative phases of the voltages at the ends of the different windings, also fall within the scope of this invention. In particular, by inverting the phase of the secondary windings (**2** and **4** shown in figure 1) with respect to that of the primary windings (**1** and **3**), formula (2) changes to **Vs = (V1 - V3)/2**

and, as a consequence, formula (9) changes to **Vo = Vs (1 + 2 • k • N2/N1)**. Thus, this alternative choice enables to attain a higher sensitivity.

As previously discussed with reference to the known transducers (of the LVDT or the HBT type), the use of the linear inductive transducers in measuring and control devices and apparatuses is quite widespread and varied, and the comparator shown in the herein mentioned patent US-A-4,386,467 represents just one of the many possible applications for transducers **T** and **T'** according to the present invention.

CLAIMS

1. A linear inductive transducer (**T**) including
- electric windings (**1-4**) with
  - a primary winding (**1**), and
  - a pair of secondary windings (**2,4**),
- a magnetic core (**8**), for performing linear displacements relative to the electric windings,
- a pair of input terminals (**5,6**) electrically connected to said primary winding (**1**) and adapted for being electrically connected to a power supply unit (**C,11,13**),
- at least an output terminal (**7**) electrically connected to said electric windings (**1-4**),

the transducer (**T**) being adapted for providing, through the output terminal (**7**), an electric signal (**Vo**) indicative of the mutual position between said electric windings (**1-4**) and said magnetic core (**8**),

characterized in that the electric windings include a second primary winding (**3**) between said primary winding (**1**) and an input terminal of said pair (**5,6**), the primary windings (**1,3**) being electrically connected to each other and to said pair of secondary windings (**2,4**), said electric signal (**Vo**) including a first (**Vs**) and a second (**Vs'**) component, indicative of the mutual position between the magnetic core (**8**) and said primary windings (**1,3**) and said secondary windings (**2,4**), respectively.

2. The transducer according to claim 1, wherein the primary winding (**1**) and the second primary winding (**3**) are mutually connected in series at a connection point (**9**), the secondary windings (**2,4**) being electrically connected to said connection point (**9**).

3. The transducer according to claim 2, wherein each of said primary winding (**1**) and second primary winding (**3**) provides a signal (**V1,V3**) that is variable as the mutual position between said primary winding (**1**) or second primary

winding (3) and said magnetic core (8) varies, the first component (**Vs**) of said electric signal (**Vo**) being proportional to the difference between the signals (**V1,V3**) provided by the primary windings (**1,3**).

4. The transducer according to claim 3, wherein the secondary windings (**2,4**) are mutually connected in phase opposition.

5. The transducer according to claim 4, wherein each of said secondary windings (**2,4**) provides an induced signal (**V2,V4**) that is variable as the mutual position between said electric windings (**1-4**) and said magnetic core (**8**) varies, the second component (**Vs'**) of the electric signal (**Vo**) being proportional to the difference between said induced signals (**V2,V4**).

6. The transducer according to one of the preceding claims, wherein said primary winding (**1**) and said second primary winding (**3**) have the same number (**N1**) of turns, and each of said secondary windings (**2,4**) has the same number (**N2**) of turns as the other.

7. The transducer according to one of the preceding claims, wherein said power supply unit includes two sinusoidal voltage generators (**11,13**) connected in phase opposition.

8. A linear inductive transducer (**T'**) including

- electric windings (**21-24**) with
  - a primary winding (**21**), and
  - a pair of secondary windings (**22,24**),
- a magnetic core (**28**) for performing linear displacements relative to the electric windings,
- a pair of input terminals (**32,34**) electrically connected to said primary winding (**21**) and adapted for being electrically connected to a power supply unit

(11,13;11'), and

- output terminals (31,33,35) electrically connected to said electric windings (21-24),

the transducer (T') being adapted for providing, at at least one of said output terminals (31,33,35), an electric signal (Vo;Vo';Vo'') indicative of the mutual position between said electric windings (21-24) and said magnetic core (8),

characterized in that the electric windings include a second primary winding (23) between said primary winding (21) and an input terminal of said pair (32,34), the primary (21) and the second primary (23) windings being mutually connected in series at a connection point (29),

said output terminals include three output terminals (31,33,35) electrically connected to the ends of said pair of secondary windings (22,24) and to said connection point (29) between the primary windings (21,23),

the transducer (T') being adapted for selectively providing said electric signal (Vo;Vo';Vo'') at one (31;33) or a pair (31,35) of said three output terminals (31,33,35).

9. The transducer according to claim 8, wherein the secondary windings (22,24) are mutually connected in phase opposition.

10. The transducer according to claim 8 or claim 9, wherein two (33,35) of said three output terminals (31,33,35) are adapted for being electrically connected to one another for achieving an electric connection between the primary windings (21,23) and the secondary windings (22,24), the transducer (T') being adapted for providing said electric signal (Vo) at the other (31) of said three output terminals (31,33,35).

11. The transducer according to claim 10, wherein said electric signal (Vo) includes a first (Vs) and a second (Vs') component, indicative of the mutual position between

the magnetic core (**28**) and the primary windings (**21,23**) and, respectively, the secondary windings (**22,24**).

12. The transducer according to claim 8 or claim 9, wherein two (**31,35**) of said three output terminals (**31,33,35**) are adapted for being insulated, the transducer (**T'**) being adapted for providing said electric signal (**Vo'**) at the other (**33**) of said three output terminals (**31,33,35**).

13. The transducer according to one of claims from 8 to 12, wherein said power supply unit includes two sinusoidal voltage generators (**11,13**) connected in phase opposition.

14. The transducer according to claim 8 or claim 9, wherein the output terminal (**33**) connected to the connection point (**29**) is adapted for being insulated, the transducer (**T'**) being adapted for providing said electric signal (**Vo''**) at the two output terminals (**31,35**) at the ends of said pair of secondary windings (**22,24**).

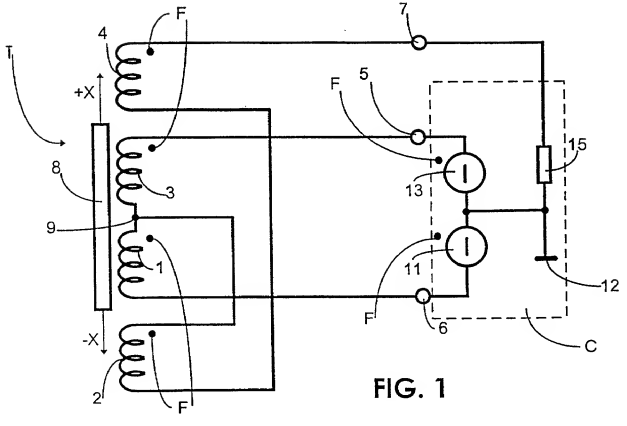
T
+X
-X
F
4
8
9
3
1
2
7
5
15
13
11
12
6
C

FIG. 1

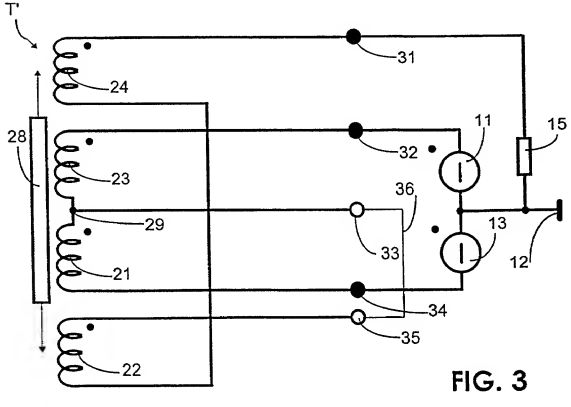
T'
24
28
23
29
21
22
31
32
11
15
36
33
13
12
34
35

FIG. 3

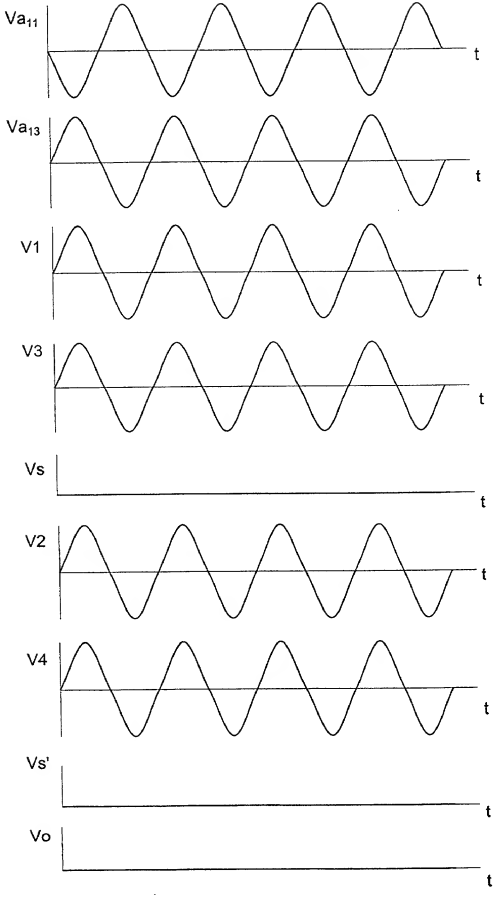

FIG. 2a

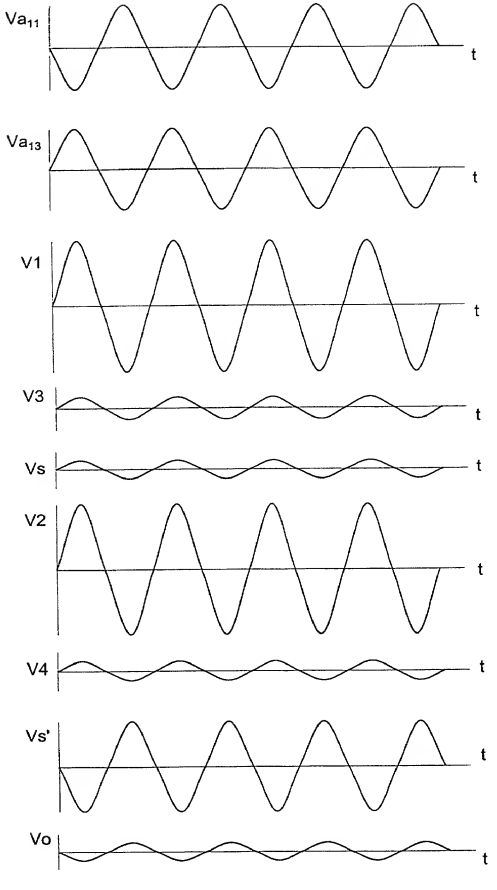

FIG. 2b

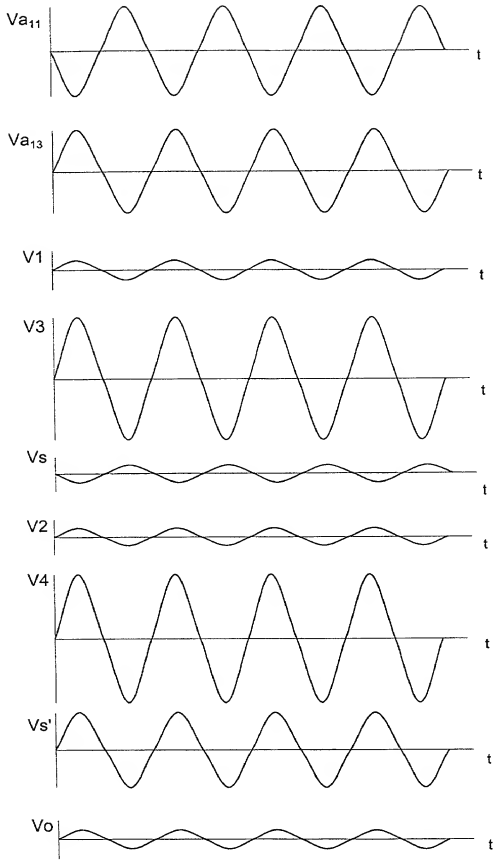

FIG. 2c

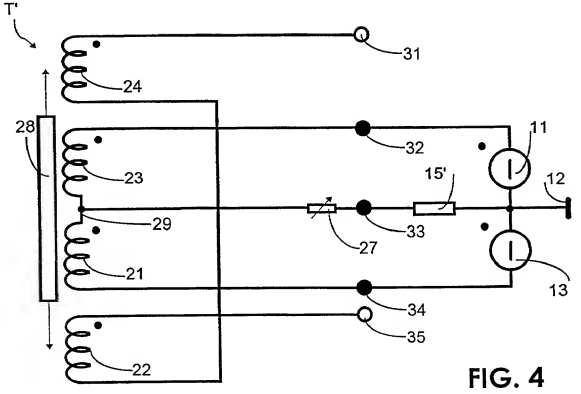
T'
31
24
28
32
11
23
15'
12
29
33
27
21
13
34
35
22

FIG. 4

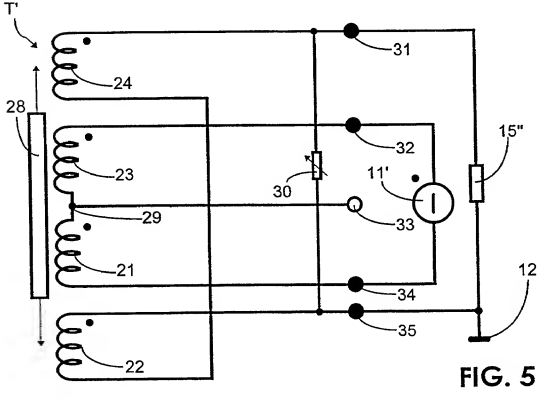
T'
31
24
28
15"
32
23
30
11'
29
33
21
12
34
35
22

FIG. 5

Attorney's Docket No:

DECLARATION AND POWER OF ATTORNEY
FOR UNITED STATES PATENT APPLICATION

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name; and

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled LINEAR INDUCTIVE TRANSDUCER

the specification of which
(check one) [X] is attached hereto.

[ ] was filed on _____ as
Application Serial No. _____
and was amended on _____ (if applicable)

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose to the U.S. Patent and Trademark Office all information which is known to me to be material to patentability to the examination of this application in accordance with Title 37, Code of Federal Regulations, §1.56 and Title 35, United States Code, §102.

I hereby claim foreign priority benefit under Title 35, United States Code, §119 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

Prior Foreign Application(s)

			Priority Claimed
PCT/EP99/07957	PCT	20/10/99	[X] Yes [ ] No
(Number)	(Country)	(Day/Month/Year Filed)	
BO98A000606	ITALY	26/10/98	[X] Yes [ ] No
(Number)	(Country)	(Day/Month/Year Filed)	
			[ ] Yes [ ] No
(Number)	(Country)	(Day/Month/Year Filed)	

[ ] Additional Prior Foreign Applications are being listed on separate sheet(s) attached hereto.

I hereby claim the benefit under Title 35, United States Code, §120 of any United States application(s) listed below and, insofar as the subject matter of any of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, §112, I acknowledge the duty to disclose to the U.S. Patent and Trademark Office all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, §1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application:

Application Serial No.	Filing Date	Status - patented, pending, abandoned
Application Serial No.	Filing Date	Status - patented, pending, abandoned
Application Serial No.	Filing Date	Status - patented, pending, abandoned

☐ Additional United States Applications are being listed on separate sheet(s) attached hereto.

As a named inventor, I hereby appoint:

10

Gary M. Hoffman, Reg. No. 26,411; Donald A. Gregory, Reg. No. 28,954; Thomas J. D'Amico, Reg. No. 28,371; James W. Brady, Jr., Reg. No. 32,115; Jon D. Grossman, Reg. No. 32,699; Mark J. Thronson, Reg. No. 33,082; John A. Wasleff, Reg. No. 36,047; Laurence E. Fisher, Reg. No. 37,131; Robert L. Hails, Jr., Reg. No. 39,702; and William E. Powell, III, Reg. No. 39,803

my attorneys with full power of substitution and revocation to prosecute this application and to receive correspondence from and transact all business in the Patent and Trademark Office connected therewith.

Address all correspondence to:

DICKSTEIN SHAPIRO MORIN & OSHINSKY LLP
2101 L Street NW
Washington, DC 20037
(202) 785-9700

The undersigned hereby authorizes the U.S. attorneys and/or agents named herein to accept and follow instructions from the agents and/or liaisons of the undersigned and/or the Assignee of this application as to any action to be taken in the Patent and Trademark Office regarding this application without direct communication between the U.S. attorney or agent and the undersigned. In the event of a change in the persons from whom instructions may be taken, the U.S. attorneys and/or agents named herein will be so notified by the undersigned and/or any Assignee of this application.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

10

Full name of sole or first inventor: Valerio DONDI

Inventor's signature: Valerio Dondi Date: 15 March 2001

Residence: CASTEL MAGGIORE Citizenship: ITALIAN

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I-40013 CASTEL MAGGIORE (BO), ITALY

Full name of second inventor: _____

Inventor's signature: _____ Date: _____

Residence: _____ Citizenship: _____

Post Office Address: _____

_____

Full name of third inventor: _____

Inventor's signature: _____ Date: _____

Residence: _____ Citizenship: _____

Post Office Address: _____

_____

☐ Additional inventors are being named on separate sheet(s) attached hereto.

Title 37, Code of Federal Regulations, § 1.56 **Duty to disclose information material to patentability**

(a) A patent by its very nature is affected with a public interest. The public interest is best served, and the most effective patent examination occurs when, at the time an application is being examined, the Office is aware of and evaluates the teachings of all information material to patentability. Each individual associated with the filing and prosecution of a patent application has a duty of candor and good faith in dealing with the Office, which includes a duty to disclose to the Office all information known to that individual to be material to patentability as defined in this section. The duty to disclose information exists with respect to each pending claim until the claim is cancelled or withdrawn from consideration, or the application becomes abandoned. Information material to the patentability of a claim that is cancelled or withdrawn from consideration need not be submitted if the information is not material to the patentability of any claim remaining under consideration in the application. There is no duty to submit information which is not material to the patentability of any existing claim. The duty to disclose all information known to be material to patentability is deemed to be satisfied if all information known to be material to patentability of any claim issued in a patent was cited by the Office or submitted to the Office in the manner prescribed by §§1.97(b)-(d) and 1.98. However, no patent will be granted on an application in connection with which fraud on the Office was practiced or attempted or the duty of disclosure was violated through bad faith or intentional misconduct. The Office encourages applicants to carefully examine: (1) prior art cited in search reports of a foreign patent office in a counterpart application, and (2) the closest information over which individuals associated with the filing or prosecution of a patent application believe any pending claim patentability defines, to make sure that any material information contained therein is disclosed to the Office.

Title 35, United States Code, § 102 **Conditions for patentability; novelty and loss of right to patent**

A person shall be entitled to a patent unless --

(a) the invention was known or used by others in this country, or patented or described in a printed publication in this or a foreign country, before the invention thereof by the applicant for patent, or

(b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of the application for patent in the United States, or

(c) he has abandoned the invention, or

(d) the invention was first patented or caused to be patented, or was the subject of an inventor's certificate, by the applicant or his legal representatives or assigns in a foreign country prior to the date of the application for patent in this country on an application for patent or inventor's certificate filed more than twelve months before the filing of the application in the United States, or

(e) the invention was described in a patent granted on an application for patent by another filed in the United States before the invention thereof by the applicant for patent, or on an international application by another who has fulfilled the requirements of paragraphs (1), (2), and (4) of section 371(c) of this title before the invention thereof by the applicant for patent, or

(f) he did not himself invent the subject matter sought to be patented, or

(g) before the applicant's invention thereof the invention was made in this country by another who had not abandoned, suppressed, or concealed it. In determining priority of invention there shall be considered not only the respective dates of conception and reduction to practice of the invention, but also the reasonable diligence of one who was first to conceive and last to reduce to practice, from a time prior to conception by the other.

Title 35, United States Code, § 103 **Conditions for patentability; non-obvious subject matter**

A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

Subject matter developed by another person, which qualifies as prior art only under subsection (f) or (g) of section 102 of this title, shall not preclude patentability under this section where the subject matter and the claimed invention were, at the time the invention was made, owned by the same person or subject to an obligation of assignment to the same person.

Title 35, United States Code, § 112 **Specification**

The specification shall contain a written description of the invention, and of the manner and process of making and using it, in such full, clear, concise and exact terms as to enable any person skilled in the art to which it pertains, or with which it is most nearly connected, to make and use the same, and shall set forth the best mode contemplated by the inventor of carrying out his invention. ...

Title 35, United States Code, § 119 **Benefit of earlier filing date in foreign country; right of priority**

An application for patent for an invention filed in this country by any person who has, or whose legal representatives or assigns have, previously regularly filed an application for a patent for the same invention in a foreign country which affords similar privileges in the case of applications filed in the United States or to citizens of the United States, shall have the same effect as the same application would have if filed in this country on the date on which the application for patent for the same invention was first filed in such foreign country, if the application in this country is filed within twelve months from the earliest date on which such foreign application was filed; but no patent shall be granted on any application for patent for an invention which had been patented or described in a printed publication in any country more than one year before the date of the actual filing of the application in this country, or which had been in public use or on sale in this country more than one year prior to such filing.

No application for patent shall be entitled to this right of priority unless a claim therefor and a certified copy of the original foreign application, specification and drawings upon which it is based are filed in the Patent and Trademark Office before the patent is granted, or at such time during the pendency of the application as required by the Commissioner not earlier than six months after the filing of the application in this country. Such certification shall be made by the patent office of the foreign country in which filed and show the date of the application and of the filing of the specification and other papers. The Commissioner may require a translation of the papers filed if not in the English language and such other information as he deems necessary.

In like manner and subject to the same conditions and requirements, the right provided in this section may be based upon a subsequent regularly filed application in the same foreign country instead of the first filed foreign application, provided that any foreign application filed prior to such subsequent application has been withdrawn, abandoned, or otherwise disposed of, without having been laid open to public inspection and without

leaving any rights outstanding, and has not served, nor thereafter shall serve, as a basis for claiming a right of priority.

Applications for inventor's certificates filed in a foreign country in which applicants have a right to apply, at their discretion, either for a patent or for an inventor's certificate shall be treated in this country in the same manner and have the same effect for purpose of the right of priority under this section as applications for patents, subject to the same conditions and requirements of this section as apply to applications for patents, provided such applicants are entitled to the benefit of the Stockholm Revision of the Paris Convention at the time of such filing.